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RIVERFRONT LAND-USE PLANNING IN URBAN AREAS

A THESIS

Presented to

the Faculty of the Graduate Division

by

Frederick S. Kerpel

in Partial Fulfillment

of the Requirement for the Degree

Master of City Planning

Georgia Institute of Technology

May 1960

BA
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RIVERFRONT LAND-USE PLANNING IN

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ACKNOWLEDGMENTS

The author wishes to thank Professors H. K. Menhinick and M. G. Little, whose guidance and council concerning the organization and writing of this thesis were invaluable. Thanks are also expressed to Professor C. E. Kindsvater for supervising this thesis.

Gratitude is also due to Mr. Aelred Gray of the Tennessee Valley Authority, Knoxville, Tennessee; Mr. D. P. Billard of the U. S. Army Corps of Engineers, Atlanta, Georgia; and the personnel of the Library of the Georgia Institute of Technology for their aid in obtaining information needed for this study.

A special note of gratitude is due to the author's wife, whose effort and patience made this course of study and consequently this thesis possible.

SUMMARY

Riverfront lands in urban areas which have been allowed to deteriorate over the years have again become important because of a demand for this waterfront land by water-related uses. These water-related uses, particularly the ones that require deep-water frontage, are often finding riverfront lands pre-empted by uses that do not require the use of the river for their operations.

Since riverfront land in most cities is scarce, it would seem advantageous for a city to reserve this land for those water-related uses for which a riverfront location is necessary. Among these uses are: industry that uses the river for shipping of finished goods and raw materials; industry that requires large amounts of water that cannot be pumped economically; recreation in the form of marinas and swimming areas where water conditions permit; and utilities plants such as water and sewage treatment and gas manufacturing. In addition, there are certain riverfront lands subject to floods which preclude the construction of buildings on such land. This land, however, can be put to use for recreation and agriculture or other open type uses.

Planning a riverfront requires some special studies of physical conditions, river transportation potential, recreation needs and land use. All of these studies have a vital role in arriving at a future plan for the riverfront. The tools with which to carry out the future plan include zoning ordinance provisions, an industrial development commission, a public-works program with joint federal participation

that would include filling and dredging operations and construction of protective works.

After many years of disuse, riverfront lands may again become important to many cities. It is hoped that this study will aid in the future development of riverfront land in a unified and orderly fashion so that a city may take advantage of one of its most valuable and natural assets.

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CHAPTER I

INTRODUCTION

In the past decade, numerous cities lying on inland waterways of the United States have taken a renewed interest in their riverfront lands. This interest has been fostered by the increased demand of water transportation and of industrial and recreational uses for riverfront lands. In many instances, large amounts of waterfront land have been so haphazardly developed as to be virtually useless for such purposes; in others, development has been neglected.

The revival of commercial navigation on inland waterways has helped bring these problems into sharper focus. For many years, inland waterways were the major transportation routes because a network of railroads and highways was not yet in existence. With the development of the steam engine and the building of railroads, commercial navigation declined sharply. The development of the trucking industry and a comprehensive system of highways also had a deleterious effect upon commercial navigation. In recent years, however, commercial navigation has been growing at a steady rate; the growth has resulted chiefly from two new technological developments, diesel power and radar (1). The development of larger, more powerful diesel engines has made possible towboats capable of moving large numbers of fully loaded barges. The development of radar has eliminated the need to anchor at nightfall or during a heavy fog. These developments have enabled shipping companies to offer faster service and much lower transportation rates

for certain commodities than rail or truck companies. Low water transportation rates are possible chiefly because of the large amount of cargo a tow of barges can carry at one time. For example, over three million gallons of fuel oil--the equivalent of four hundred railroad cars--have been transported in a single tow. Bulk cargo makes up the majority of the tonnage shipped on the inland waterway system at present; however, manufacturers of finished goods are also beginning to take advantage of water transportation.

This interest in low-cost transportation and the realization that the inland waterway system can provide access to many major industrial and agricultural areas as well as access to areas providing raw materials have helped accelerate the improvement of many navigable channels. Large portions of many rivers, including the Cumberland, Delaware, Hudson, Illinois, Mississippi, Missouri, Ohio, and Tennessee, and sections of many lesser rivers are now navigable as a result of improvements made during the course of the last few decades. With the Atlantic and Gulf Intracoastal Waterway, these rivers form an interconnected system over 10,000 miles long with a minimum channel depth of nine feet. The newly opened St. Lawrence Seaway is an important addition to the system.

Accessibility by boat to many sources of raw materials and the low cost of transporting these materials have caused certain types of industry to seek locations on riverfronts. Those industries which do not use the river for transportation purposes but require large amounts of water in their manufacturing processes have also been seeking riverfront locations. The former type of industry usually requires

COURTESY OF U.S. ARMY CORPS OF ENGINEERS

FIG. 1 MAP OF INLAND WATERWAYS
(WITH INTRACOASTAL SYSTEM)

deep-water frontage while the latter requires only a waterfront location to facilitate the pumping of water to plants. The combination user, one that uses water for both transportation and manufacture, makes fullest use of the river potential.

Another waterfront use that has only recently become important is recreation. The use of waterfront lands for marina development has become a profitable venture because of the increasing number of boat enthusiasts. Such marinas located in urban areas can be a decided advantage for the city dweller who must otherwise drive many miles to launch his boat. Swimming and water skiing are also becoming more popular. On rivers where pollution is not a problem, these forms of recreation are uses that require a waterfront location.

The demand for waterfront space by commercial navigation, industry and recreation has presented cities with numerous problems. Many cities have found that their available riverfront lands are definitely limited and their deep-water frontage even more so. Furthermore, these lands, in many instances, have been taken over to a large extent by inappropriate land uses which have no relation to or need for a riverfront location. Many cities have found that the riverfront is occupied chiefly by mixed land uses which are in a state of decay and are of little value. In many such cases, only complete clearance and planning can solve the problem. Even cities with less drastic riverfront problems and cities with virtually undeveloped riverfronts will find it advantageous to study and plan for the future development of their riverfront lands as a city's riverfront is a form of water resource that should be utilized to its maximum extent.

This study deals with appropriate land uses for urban riverfront lands and a general program for urban riverfront land-use planning. Some cities may find that they have space for all the principal types of waterfront uses on their riverfronts, while others may find their riverfront lands so limited that only one or two types of uses can be considered. In any event, it is hoped that this work may serve as a guide to local planning agencies.

CHAPTER II

APPROPRIATE LAND USES ON RIVERFRONTS

Limited riverfront land in urban areas has in the past often been monopolized by uses that do not require water frontage. To take full advantage of the waterfront, planning for appropriate uses that require a waterfront location should be undertaken. To facilitate the planning for appropriate land uses on riverfronts in urban areas, the classification of land uses and their water requirements should be considered. Land available for waterfront development should then be classified according to water depths and topography to determine where river-related uses should be located. The classification of land uses may be listed as follows:

1. Uses utilizing commercial navigation.
2. Uses utilizing large quantities of water.
3. Uses utilizing access to water.
4. Uses utilizing visual access.
5. Uses subject to only minor damage from floods.

Uses utilizing commercial navigation will require water depths at the shoreline of 11 feet or more in order to accommodate fully-loaded barges. Uses utilizing large quantities of water should be located where shoreline water depths are at least five feet in order that intake equipment may be accommodated. Uses utilizing access to water should have minimum water depths of five feet to accommodate small craft. For uses that utilize the river for visual access, water depths are unimportant so long as periods of low water do not leave exposed mud flats. Uses subject to only minor damage from floods may be located

in the flood plain where water depths will vary with the severity of floods.

Uses Utilizing Commercial Navigation

Terminals

Uses utilizing commercial navigation require deep-water frontage. Terminals are used for loading and unloading cargo and for storage and transfer of cargo to other means of transportation. Terminals fall into two categories, those operated by water carriers or terminal companies and those operated by and used solely by individual industries along the river. The former usually handle general cargo; the latter, usually handle only bulk commodities for use by the industries involved. It should be pointed out that at present the majority of bulk commodity shipments on the inland waterway system either originates or terminates at industries along the waterways. The need for terminals, therefore, is greatest where many industries are located on the river. Two examples of this are found on the Tennessee River and the Illinois Waterway. On the Tennessee River, there are five general cargo terminals available to all carriers as compared to 75 special purpose terminals (2). On the Illinois Waterway, there are 16 general cargo terminals available to all carriers as compared to 128 special purpose terminals (3). It would appear that terminals operated for the transfer of general cargo constitute a very limited use of the shoreline.

In order that a standard barge with a draft of nine feet may anchor at a terminal, it is essential that water depth at that point be 11 feet. Depths of up to at least 27 feet are necessary where

transfer to larger, deep-draft vessels is desired, as on the St. Lawrence waterway. In addition to adequate water depths, several facilities are required for the operation of a terminal.

Terminal facilities.--The most important facility required in a terminal is the wharf from which ships will load or unload their cargoes. Several types of wharf have been developed to meet differing shoreline and channel conditions; they include the pier, the quay, and the dock. Wharves generally extend into the water; the distance they extend will depend upon the type of ships expected to dock, water depths, and other channel conditions. However, there are restrictions on the distance a wharf may extend into the water. The distance will depend upon the location of bulkhead and pierhead lines established by the U. S. Army Corps of Engineers. The bulkhead line is the line to which any enclosed or solid-walled wharf may be constructed; the pierhead line, which usually extends farther into the water, is the line to which any open wharf supported on piles or caissons may be constructed. The types of wharves that may be constructed within these limits are numerous.

The most common type of wharf found in terminals is the pier. It is particularly useful where shoreline frontage for wharves is limited but the waterway is wide. The pier is simply an elongated wharf which usually projects at a 90 degree angle from the shoreline to a distance a little longer than the longest barge expected to use it. The width of the pier may vary from 100 to 400 feet, depending upon the facilities to be provided on the pier. The facilities on the pier usually include a transit shed for the temporary storage of goods and the apron. The apron extends from the transit shed to the edge of the pier

and may contain one or several railroad tracks in addition to space for trucks. At a port terminus of an inland waterway, two piers are often placed parallel to each other with water space between them. The water space, known as the slip, should be wide enough to accommodate four barges. This permits barges to load or unload on the off-pier side of barges or ships anchored to the piers.

Another type of wharf is the quay which extends along the shore parallel to the shoreline. This type of wharf is particularly useful where the waterway is too narrow to permit the construction of a pier or a series of piers (4).

Special types of wharves are usually constructed where there are large fluctuations of water level caused by tidal action or flood control. Along rivers where water-level fluctuation may be substantial for extended periods of time, paved, sloping levees, wharf boats, and multi-level transit sheds may be used (5).

A recent innovation utilizes caissons and covered barges. In this system, two parallel rows of widely spaced caissons are sunk into the river bed. Rings attached to the sides of a float slide up and down on the caissons as the water level fluctuates. Such a float may be a covered barge. The caissons thus serve as a vertical guide and also prevent barges from floating away. This wharf may be made up of a number of floats which serve the double purpose of providing storage area and a place to load and unload boats. Boats anchored to the wharf can be unloaded by a self-propelled, portable crane which transports the cargo to a storage area on land or places it directly on

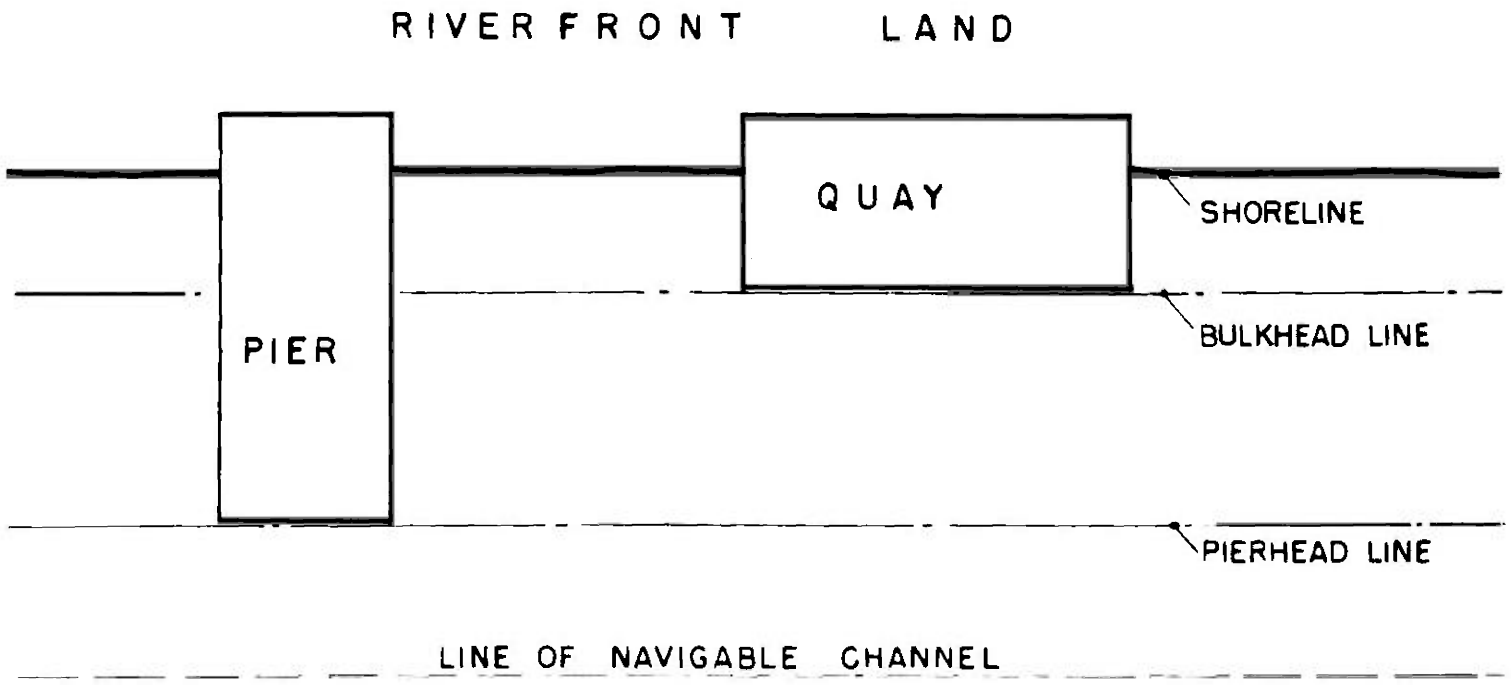

FIG. 2 DRAWING OF RELATIONSHIP OF PIERHEAD AND BULKHEAD LINES

another conveyance. In an article in the February, 1959, issue of Civil Engineering such a wharf is dealt with, and an installation on the Gironde River in France is described.

One other type of wharf deserves mention--the off-shore wharf. This type of wharf is constructed perhaps several hundred feet, or more, from shore to permit the loading or unloading of larger deep-draft vessels where water depths at the shoreline are too shallow to accommodate such vessels. Cargo is taken from the wharf to shore either by a system of belts or an aerial tramway. An off-shore wharf is particularly suitable where the river widths are great and where the wharf will present no hindrance to navigation.

An off-shore wharf was recently constructed on the Mississippi River near Baton Rouge, Louisiana as part of a new port development (6).

In addition to the wharf facilities required, numerous mechanical devices to facilitate cargo handling are also needed. Hoists of various sizes are found on many ships but additional hoisting equipment is needed on the wharf. This equipment is generally a crane operating on tracks placed on the apron of the wharf. Also very common is the portable crane which may move from the dock apron to land-based storage facilities perhaps several hundred feet from the wharf. Stacking cargo on small raised platforms called pallets placed on the dock apron makes it possible for fork lift trucks to easily move cargo to warehouses or transshipment vehicles.

Special equipment for the handling of single commodities may be found in both general cargo and special purpose terminals. Among

the many commodities which require such equipment are oil and other liquids, grain, coal, and sand and gravel. Large sites are generally required for such commodities because of their storage requirements. Storage facilities for coal, sand and gravel may be simply the space to stockpile them. Elevators may be required for the storage of grain. Oil storage tanks must be so placed and diked that a fire in one tank will not cause other tanks to ignite. If large sites are not available and storage space is severely limited, the terminal must provide facilities for prompt transshipment.

Recent innovations in cargo handling.--The rising cost of conventional methods of handling cargo has led to the development of roll-on-roll-off, lift-on-lift-off, and container shipping.

Roll-on-roll-off shipping is the transportation of loaded railroad cars or trailer trucks by barge or other water carrier. The transportation of a fully loaded railroad car or trailer truck eliminates the cost of unloading the cargo, transferring it to a ship, and possibly reloading it into another railroad car or trailer truck at its destination. The barges used in roll-on-roll-off operations are so constructed as to provide their own bridge between the hull and the wharf over which trucks or railroad cars, or both, can be rolled on or off. A recent development is a multitiered arrangement with interior ramps in ships and a self-leveling bridge attached to the wharf. Since grades should not exceed 12 per cent for trucks and six per cent for railroad cars, many difficulties in wharf and ship design may be encountered because of varying water levels (7).

Railroad cars and trailer trucks may also be loaded on barges by crane. In this case a bridge is not needed and the operation is classified as lift-on-lift-off.

Since the storage of freight cars and trailers on barges or ships entails a waste of space, e. g., space between the underside of the carrier and the deck, research is being conducted on the use of only the rail car or trailer body. In this system, bodies which, in effect, become containers, are lifted on to the water carrier and stacked atop each other utilizing the space formerly taken up by wheels. The problem then becomes one of container research, since different goods will have different requirements for containers.

Physical requirements for roll-on-roll-off and container terminals do not differ radically from those for other terminals. Rail and road connections are essential, of course; the roll-on-roll-off will probably require more rail sidings than other types of terminals. There should be enough trackage to hold at least one boat load of cars. One difference between roll-on-roll-off and container terminals and conventional terminals is that enclosed warehousing is not essential for the former types since goods are shipped in weathertight containers. If container shipment is fully developed, it could eventually lead to terminals which would consist of only a wharf and portable crane with a large paved area for the open storage of containers.

Rail and highway connections.--Rail connections to a terminal are of great importance. Desirable rail connections consist of sidings and spurs at wharves and warehouses with connections to a belt railroad system which may also serve industries near the riverfront. In

addition, the belt system could also connect with rail classification and marshalling yards located away from the riverfront.

Adequate road connections are essential since many goods are hauled from the wharf to their destinations by truck. A road of ample width with heavy-duty pavement should connect the terminal area with the highway system. It would normally parallel at least a portion of the shoreline. Its distance from the shoreline will depend to a large extent upon the facilities to be provided in the terminal. It should be so situated as to allow space for warehouses, rail facilities, parking, and open storage. The points where the road meets the existing major street system of the city should also be carefully studied to minimize conflicts which may occur between heavy terminal-related traffic and other traffic.

Industrial Uses

Only those industries that utilize commercial navigation should be permitted to locate on limited deep-water frontage.

Types of industry.--The types of industry that utilize commercial navigation extensively are usually heavy industries. These industries are the largest consumers and producers of commodities that can be shipped economically by barge. Riverfront locations for such industries enable them to dispense with rail or truck transshipment of both raw materials and finished products to and from their industrial sites and the river. This, of course, means added savings on transportation for such industries.

The bulk commodities most frequently shipped on rivers include:

1. Bituminous coal and lignite.
2. Sand, Gravel, and crushed rock.
3. Petroleum and petroleum products.
4. Grain and grain products.
5. Pulp, paper, and paper products.
6. Chemicals and chemical products.
7. Finished and semi-finished steel and scrap.
8. Lumber and lumber products.

The major types of industries likely to use one or more of the commodities listed include:

1. Food and kindred products industries, which include grain mills, food processing plants, and meat packing plants.
2. Lumber and wood industries, which include sawmills, veneering mills, millwork and plywood plants, and prefabricated lumber products plants.
3. Pulp, paper and products industries, which include pulp mills, paper mills, paperboard and other paper products plants.
4. Chemicals and chemical products industries, which include plants producing acids, chlorine, plastics, paints and varnishes, fertilizers and industrial chemicals.
5. Petroleum and coal products industries, which include refining and lubricant plants.
6. Stone, clay and glass products industries, which include glass, cement, structural clay, brick and tile, and concrete and plastic plants.
7. Primary metal products industries, which include metal furnaces and mills, and iron and steel foundries.
8. Fabricated metal products industries, which include hardware, heating and plumbing equipment and structural metals plants.
9. Machinery industries, except electric, which include farm and construction machinery plants.
10. Transportation equipment industries, which include ship, boat, and barge yards, and motor vehicle plants.
11. Utility industries, which include gas, electric and steam plants.

The primary metals products group serves as an example of a type of industry that may use commercial navigation advantageously to ship its raw materials and finished products. A steel rolling mill could have coal and scrap metal shipped to its site by barge; it could ship its finished products, sheet steel, reinforcing rods, etc., by barge. Petroleum production plants are another example of an industry that may use the river to advantage for commercial navigation. Crude oil may be shipped to a refining plant for processing. The finished products, gasoline, kerosene, or any by-product, can then be shipped again by barge. Most of the other types of industries listed can use the river for transportation of raw materials as well as finished products. Some plants, such as utilities, may make use of the river only to receive materials such as coal. Others, such as ship building yards and automobile assembly plants, may use the river only for shipment of finished products. Many plants may, in addition, use the river as a source of water for manufacturing processes.

Site requirements.--The site requirements of these types of industry will vary, depending upon production capacities of the plants and the production methods to be used. One requirement all have in common is the need for deep-water frontage to accommodate barges that are to use the terminal facilities. If the production capacity of a plant is to be great, a large wharf area stretching over considerable river frontage may be necessary to provide for the unloading and storage of raw materials to eliminate extra handling of cargo. In addition, a site of several hundred acres may be needed to accommodate all the required structures, parking areas, etc. The production method of a plant is

also important in determining the size of the site and the amount of land with deep-water frontage it will require. The terminal should be so located as to form an integral part of the production process. It would appear advisable to encourage the location of the remainder of the structures needed back from the river rather than along the river in order to conserve deep-water frontage. A minimum of 200 feet of water frontage is necessary to accommodate most barges in use today.

Additional space may be required by industries that use the river not only as a transportation medium but also as a source of water in production processes. If the industry requires the addition of purifying agents to raw water or if settling basins, or both, are needed, space will be required for these facilities. If the effluent contains impurities, such as dyes or poisons, or is very hot, large open ponds would be required for the settlement of impurities or the cooling of the effluent. An example of a plant in which raw water purification is required is a steel rolling mill. Chemicals may have to be added to the raw water to prevent the growth of algae in the water distribution system. The need for cooling ponds is best illustrated by the situation found in Youngstown, Ohio. There the effluent of many steel mills is discharged into the Mahoning River with the result that the temperature of the river has been known to rise as high as 140 degrees Fahrenheit (8).

Uses Utilizing Large Quantities of Water

Many industrial, agricultural and utility operations that require large quantities of water for production purposes should be

considered for location on the riverfront. Some of them also utilize water transportation. If commercial navigation is not a requirement, water depths may be approximately five feet or more.

Industrial Uses

Industries that require large quantities of water that cannot be economically pumped over long distances or taken from the city's water system may appropriately be located on the waterfront. After some purification, water is used by industries for one or more of the following: processing, cooling and air conditioning, boiler feeding, and sanitary services. The effluent may require some form of treatment before it can be released into the river.

Among the industries that may seek a location accessible to large quantities of water are:

1. Chemicals and chemical products industries, which include acid, chlorine, paint and varnish manufacturers and plastics plants.
2. Primary metal products industries, which include iron and steel foundries and furnaces.
3. Petroleum and coal products industries, which include petroleum refineries.
4. Pulp, paper and products industries, which include paper mills, paper coating and glazing products plants.
5. Food and kindred products industries, which include canned and frozen food plants, grain products plants, sugar refineries, meat packing and beverage plants.

The exact amount of water each industry will require will depend upon the capacity of the plant and its production method. Generally, each of the industries listed above would use more than one million gallons per day. Riverfront locations are essential for such plants as few municipal systems can supply water in such volume at a cost the industry can afford.

Agricultural Uses

The use of riverfront land at the edge of an urban area for truck farms should be considered. In recent years, the increased need for irrigation has made access to large quantities of water more important to the farmer. A farm irrigation system might necessitate only the placement of one or more pumps at the shoreline. If the amount of water to be drawn from the river is considerable in relation to the supply, riverfront land reserved for agriculture should be so located that downstream uses will not be adversely affected. Another problem to be considered is the extent, source, and type of pollution of the river. Pollution may be detrimental to crops and may preclude or severely limit the use of riverfront land for agriculture.

Utility Plants

Access to large quantities of water is a necessity for municipal water-supply systems. Since water-treatment plants require large sites, the use of limited riverfront lands for water-treatment plants should not be considered. However, one or more small areas must be provided for intakes and perhaps pump houses to supply the treatment plant located farther inland. Such an area would require in addition to pump houses, only a road and parking space for several vehicles.

Sewage disposal plants also need access to large quantities of water for the dilution of the effluent. The location of the outlet for the effluent requires careful consideration in order that downstream uses will not be adversely affected. In addition, sewage disposal plants need large sites to provide space for settling basins,

filters, sludge beds, several small buildings and parking area for a few cars and trucks. The latter facilities need not be located directly on the waterfront.

Steam plants for the production of electricity require very large amounts of condensed cooling water. Since the water is used in condenser tubes, some treatment of the water may be required to prevent the formation of deposits in the tubes. Space would be needed for water treatment with the size dependent upon the condition of the raw water. In certain cases a small settling pond might be needed, while in other cases water could be pumped directly from the river to the tubes. In addition to water-treatment facilities, a steam plant also requires a large, open area for the storage of coal. If the coal is transported by rail, facilities such as lead-in tracks and spurs for hopper car storage would be needed. The number of spurs and their lengths would be determined by the steam-generating capacity of the plant.

The structure housing the tubes and other concomitants will be of considerable size. When water treatment facilities, rail facilities, coal storage facilities and parking areas are added to the structure the total area will encompass several acres.

Uses Utilizing Access to Water

Riverfront lands that are suitable for uses requiring water access need water depths of at least five feet at the shoreline. Such lands are suitable for parks and recreation purposes, a use some cities have overlooked in the past development of their riverfront

lands (9). The recent interest in boating may make a marina an important concomitant of a park and recreation area.

Parks

In many cities, a river crossing is the main point of entry. For such cities, the development of a park at a bridge crossing the river could be scenic and make a favorable impression upon visitors. A fine example of such planning is the city of Guntersville, Alabama, which has developed a small park where the highway enters the city (10).

Facilities.--The facilities that may be provided in a riverfront park will depend upon the amount of land available and the need for recreation facilities. The amount of riverfront land available for parks and recreation may be very limited. Some cities may find their riverfront land so limited that only a small green area with walks, benches, and parking space can be developed. If the pollution of the river is not a problem, one important facility that should be considered for a riverfront location is a bathing beach. For the city dweller removed from lakes or the seashore, who must otherwise rely on swimming pools, a large, clean bathing beach would be a distinct boon. A bathing beach would also need large parking lots, dressing rooms, refreshment stands, and protection for the swimmers from passing boats.

The extent to which these facilities are provided will depend upon the city's need for certain facilities in the overall parks and recreation program. It is the rare city that has enough parks to meet the needs of its population at the present time. If such a situation does exist, however, land for future parks along the riverfront should be reserved while it is still available.

Highway access.--Highway access to the park and recreation area will require careful study, particularly if it is to contain facilities such as a bathing beach which will tend to make it a regional attraction to and from which traffic will be heavy. A highway paralleling the river but so located that it will not divide the recreation area is desirable. This highway could extend the entire length of the park and provide a scenic drive. Where a highway crosses a river, the bridge could be a convenient buffer between different uses, especially if it is located where there is a decisive change in water depth. Access to the various recreation facilities could be from a service road located parallel to the highway and connected to the highway by one or more interchanges. In addition to the highway and service road, drives for access to the various facilities within the park should be so located as to take advantage of the scenery.

Marinas

The increase in the number of boating enthusiasts has made the development of marinas an important feature of many waterfronts. During the last few years, substantial sales of pleasure boats of all kinds have been reported (11). A large part of the increase in sales is attributable to urban dwellers for whom a marina located along the city's riverfront would be a decided advantage.

Site requirements.--There are two types of marinas: the waterfront marina and the harbor marina. The waterfront marina may require a breakwater wall to protect the mooring area from wave action caused by passing boats and winds. Pierhead and bulkhead lines may restrict the

size of the marina if insufficient land is available to extend the marina parallel to the shoreline. The harbor marina is usually in a small, protected cove. Since it is protected naturally by land, a breakwater wall is not required and at least three sides of the harbor can be used for mooring space. The natural land protection lessens possible damage from storms.

Fluctuation of water levels is a factor that could restrict the location of a marina. On rivers where fluctuation is considerable because of draw-down for flood control, the marina mooring facilities and boats may be left on mud flats if not properly located and designed. Mooring facilities are sometimes so constructed that they can be moved as the waterline recedes. Where water levels fluctuate less than four feet, with a minimum depth that permit boats to remain afloat, fixed piers may be constructed. However, if fluctuation of more than four feet is common, floating piers should be constructed. This would apply particularly on large, main streams such as the Mississippi, Missouri, or Ohio Rivers and to flood control lakes along the Tennessee River where considerable variations in water level occur (12).

Facilities.--The required marina facilities can be separated into off-shore and on-shore facilities. Off-shore facilities include:

1. Breakwater wall, if needed.
2. Piers on piles or floating wharves with sufficient room for maneuvering.

On-shore facilities that may be provided include:

1. Bulkhead or stone rip-rap for shore protection.
2. Launching ramps large enough to accommodate several boats at once.

3. Vertical lift hoists capable of lifting boats from trailers and lowering them into water.
4. Repair and storage sheds, preferably enclosed, with mono-rail from the storage sheds to vertical lift hoist which lowers and raises boats into and out of the water and lockers for storage of motors, life preservers, etc.
5. Sales facilities, including gasoline, fishing supplies, and ice.
6. Restaurant and snack bar.
7. Parking areas for automobiles and boat trailers.

Additional facilities that may be included are:

1. Club houses for yacht clubs, sea scouts, and the like.
2. Related recreational facilities such as a swimming pool, a model boat pool, small play area for children, picnic area.
3. Fishing pier at the outer boundary of the marina.
4. Boat sales and display areas.
5. Motels for tourists.

It can readily be seen from the above lists that a marina can be a sizeable operation and that the size of the site depends entirely upon the number and size of the facilities to be provided.

Uses Utilizing Visual Access

Extremely hilly terrain or steep bluffs adjacent to a river usually afford a scenic view of the river and other surrounding areas. Physical access to the river from such sites is often impossible or impracticable and such land may, therefore, be classified as land suitable for visual access. Because of the hilly terrain and lack of physical access to water, land uses other than residential and park uses may be precluded. The development of these two uses in such areas, however, may be limited by the types of adjacent land use.

Residential Use

If the uses immediately adjacent to the bluffs or hilly area are not noise- or smoke-producing and do not present an unsightly view, the area may well be suitable for high-value residential development. If this is the case, a riverfront highway, if it is needed, should be routed in this area in such a way that passing traffic will not disturb the view or detract from the area by reason of noise and fumes. Where a two-level scheme can be developed, however, with the highway on the lower level and residences on the upper level, very little, if any, noise or fumes will be evident in the residential area. The direction of the prevailing winds would also have to be considered to avoid having smoke and fumes that may originate in other areas along the riverfront drift over the residential area. One additional point that must be considered is the proximity of a marina. The noise from a marina caused by outboard and other boat motors could make an area adjacent to the marina highly undesirable for residences.

Parks and Recreation Use

In areas with visual access that are not suitable for residential subdivision because of rugged terrain, park areas may constitute a suitable use. Since the terrain may be hilly and often heavily wooded, the land may be appropriate for passive recreation. Walks, benches, and picnic areas placed in locations that take advantage of the view would be desirable. A riverside highway in this area should be routed where traffic noise and fumes will least affect the activities in the park.

Uses Subject to Only Minor Damage from Floods

Riverfront land in the flood plain may be utilized by uses subject to only minor damage from floods. Such land is almost flat, protective works may not be feasible, and it is subject to periodic flooding. The flood plain consists of the floodway and the impounding areas. The floodway is that part of the channel and the adjacent flood plain needed to permit flood waters to pass naturally. Generally water depths exceed two feet and water velocities are high in the floodway (13). To prevent flood damage and to facilitate the flow of flood waters, enclosed structures should not be permitted in the floodway. The prohibition of enclosed structures, however, does not preclude the utilization of this land for productive use. Impounding areas are areas in which floodwaters are temporarily stored. Although water depths and velocities are generally low, extensive silt and water damage may occur in impounding areas.

Permissible Uses in Floodways

Commercial uses.--The provision of parking facilities for customers in the downtown area is a necessity common to most cities. The fringe areas of the central business district of cities on rivers may be subject to inundation. In order to utilize this land properly, open uses such as parking lots and parking decks, which are open structures, and used car lots have been suggested (14). The only damage done in this case would be the deposit of silt and debris which could quickly be removed after the flood.

Park and recreation uses.--Parks and recreation areas are additional uses that are suitable for location in the floodway. In the floodway, land may be set aside for transient amusements such as carnivals and circuses which could make use of the land during the flood-free seasons. In addition to circus and carnival grounds, space could be provided for such sports as football, baseball, and golf, as well as necessary parking space.

Another facility that could be provided in this area is a boat launching ramp. This launching ramp could be particularly useful as a supplement to a marina. If a marina is not to be provided, launching ramps will be a necessity. Launching ramps may be located at the end of an access road or on any hard surface in the area; since they would be used for small boats brought on trailers or on top of cars, they would not require any structures or other equipment. Supplies, such as gasoline, food, etc., would have to be brought in unless they could be sold from portable concession stands which could be removed in the event of flood danger.

An air strip for single-engined sport planes is another facility that could be provided on the flood plain since enclosed structures of any kind would not be required. The air strip should be so located that it will not interfere with recreational facilities. In the event of a flood, planes could be flown out of the area or rolled to higher ground not subject to flooding. Since buried gasoline storage tanks could be lifted out of the ground by hydrostatic pressure of flood

waters, gasoline should be stored in truck trailers which could also be moved in the event of a flood.

Agricultural use.--The use of the floodway for agriculture should also be considered for the edge of an urban area. Very often the soil in the flood plain is very rich because of soil deposited there by previous floods. The construction of any structure, however, would have to be prohibited. The use of this land for agriculture will depend entirely upon the risks the farmer is willing to take with his crops. Information about the frequency and time of floods is generally available, and crops can be planted that can be harvested before the flood season. The risk entailed, however, is the chance than an unexpected flood might cause the loss of the crop that year. The floodway might also be used for pasture land.

Permissible Uses in Impounding Areas

Since the uses which may be permitted to locate in the floodway are those that do not suffer extensive or frequent damage from floods, they may also be considered for location in impounding areas. Although silt damage may be severe in impounding areas, the water damage will generally be minor; since all are open uses, silt deposits could be quickly removed. In addition certain other open type uses may be permitted in impounding areas.

Commercial uses.--Commercial uses that could be located in impounding areas include drive-in theaters. Some protection from water seepage would be required for buildings. The alternative would be to place structures on higher ground. Sewage lines with self-closing valves

should be provided to prevent the backing up of sewage. Since the screen and speakers in drive-in theaters are mounted on posts several feet from the ground, little, if any, damage to them is likely to result if they are properly constructed.

Park and recreation uses.--In conjunction with a football or baseball field, a stadium could be provided with its long dimension parallel to the direction of the flood flow to minimize the piling up of silt and debris. Since the stadium may be designed as an open structure, silt and debris would be able to pass through it leaving a minimum deposit which could be easily removed.

Summary

The demand for riverfront lands by such uses as commercial navigation, industry, and recreation has increased steadily. It would appear, therefore, to be advantageous for a community to plan for appropriate land uses on its riverfront land. Appropriate land uses and their requirements have been presented in this chapter. The presentation does not imply that all of these uses must necessarily be located on the waterfront. Some cities may find that all these uses can be located on the waterfront in a unified development harmonious with the development of adjacent land in the remainder of the city. Other cities may find that only a few of the uses can be considered because of topographical conditions, river conditions, and other concomitants. The extent to which riverfront land can be utilized for such uses as have been discussed can best be determined by a group of special studies necessary to a riverfront planning program.

CHAPTER III

RIVERFRONT PLANNING PROGRAM

The previous chapter presented the appropriate water-related land uses that should be permitted to locate on the riverfront. This chapter will deal with the means by which riverfront lands can be planned and developed within the framework of a planning program.

Physical Studies

Shoreline and channel study.--The first study that should be conducted is a study of the physical condition of the shoreline and the river. This study is needed to determine the classification of land as previously outlined. A topographical map of the shoreline and the river bed and channel cross-sections would also be required. If the velocity of the channel flow is high or if wave action is a problem, shoreline erosion is likely to result. This could be a limitation on the utilization of the shoreline unless bulkheads are to be provided. Water-level fluctuation is another item that would have to be examined in this study. If severe fluctuation occurs, the location and design of waterfront facilities will have to take this fluctuation into account.

Flood study.--Generally, a flood study should be undertaken to determine the extent and location of periodic floods and the feasibility of constructing such protective works as levees, reservoirs, etc. to

control floods. If protective works prove infeasible, a plan should be prepared in which land subject to periodic flooding would be reserved for uses which are subject to only minor damage from floods. The flood study will determine the floodway and the impounding areas which will influence the location of the various uses subject to only minor damage from floods. If protective works prove feasible, a second plan should be prepared for the development of the riverfront based on conditions expected to prevail when the protective works are completed. Uses allowed to locate in such a protected area may be any water-related uses which can most effectively make use of the shoreline, topographical, and water conditions which will prevail after the completion of protective works.

Pollution study.--A river-pollution study which includes not only information on local river pollution but also on the causes of pollution and the possibilities of eliminating it by up-stream uses is necessary because severe pollution will restrict riverfront development. If industrial and municipal wastes are properly treated before being discharged, pollution can be minimized and fuller use of riverfront land can be made by industry and recreation. It should be noted that few, if any, municipal planning agencies have the necessary engineering staff capable of conducting flood and pollution studies.

Transportation Studies

Railroads.--In order to properly plan for commercial navigation and industry in the waterfront area, an inventory of existing rail facilities in the area and their location within the area is a necessity.

Frequently, rail facilities are already located in a riverfront area because rail lines in the past have taken advantage of the flat terrain in many such areas (15). This has been instrumental in the development of industrial areas to which industries were attracted because of good rail facilities. The combination of rail and commercial navigation facilities is likely to create a demand for industrial sites along the riverfront.

An important part of a railroad study would be an investigation of the number of individual rail lines presently serving the waterfront area. If future rail traffic is expected to increase substantially, recommendations might be made to establish a belt line to assure more efficient service and eliminate duplication of rail facilities. Such a study may also make recommendations regarding the ownership of such a belt line. The city might wish to retain ownership or joint ownership by two or more railroads already serving the waterfront might be considered. A third possibility is ownership of the belt system by one rail line which would charge other lines a switching rate for the use of its facilities.

It is essential that additional facilities, if they are needed, be so planned that they will not be blocked by future development of industry. For although railroads have the power of eminent domain, acquiring a developed area in order to gain additional space for rail facilities may be too costly and may preclude the possibility of providing rail facilities where they may be needed. As was pointed out earlier, the riverfront rail connections should be a part of a belt

between uses along the waterfront. If a highway is to be provided parallel to the shoreline, it may serve as a buffer between riverfront uses and adjacent uses in the remainder of the city. The location of the riverfront highway will depend to a large extent upon land-use studies.

River terminals study.--Since a cargo terminal usually represents a large capital investment, the development of general cargo facilities should be preceded by a study of the present river traffic and extensive interviews with manufacturers in the area. The interviews would be needed to help determine the amount and type of cargo likely to be shipped through the terminal by individual concerns. Such a study would also take into account regional and local resources as well as existing industries and terminal facilities. A preponderance of certain resources may be among the determining factors that will decide the amount and kind of commercial navigation that may be expected. Another important point that should be considered is that most commercial navigation originates and terminates at special purpose terminals maintained by specific industries. Few municipal agencies have the staff needed to conduct the origin and destination studies necessary to determining the need for terminal facilities. A special consultant can be called in to conduct this study.

Other Planning Studies

Park and recreation study.--A study of existing parks and recreation facilities will be essential in determining future park and recreation needs. If a city finds that it has need of water-related recreation

facilities, it is possible that the riverfront may be utilized to provide such facilities. If pleasure boating on the river is not precluded by pollution, this study should also include an analysis of the type, size, number, and condition of boating facilities in the immediate region. The type and size of boats that may reasonably be expected to use a future marina should also be determined. Population trends and boat sales in the area may help in determining marina needs.

Land-use study.--The land-use study is perhaps the most important study that must be conducted. To plan the riverfront properly requires a detailed land-use study of the riverfront as well as a land-use study of the city as a whole. Such a detailed riverfront study should include information concerning:

1. All existing land uses in the riverfront area.
2. Structural condition of existing uses in the riverfront area that are not water-related.
3. Areas of extensive blight in the riverfront area.
4. Assessed value of existing land and structures in the riverfront area.
5. Land uses in the areas adjoining the riverfront area.

The portion of the study involving existing land uses in the riverfront areas should indicate all present uses that are water-related in order to determine where the riverfront is being used to greatest advantage. The existing water-related uses might form the nucleus for future riverfront planning. For example, if a steel mill is already located on the riverfront, it might very well attract a small shipyard which manufactures barges. This portion of the study should also indicate present uses which are not water-related and which should be eventually removed from the riverfront area.

The structural condition of existing uses which are not water-related will be helpful to know in order to determine whether continued use of these structures may be expected. This information may also help determine whether alteration of existing structures for water-related uses is feasible.

Extensive blight in riverfront areas is a problem common to many cities. These areas of blight should be carefully delineated and considered for future urban renewal projects.

The assessed value of all land and structures in the riverfront area also should be known. This information will be especially useful if the city must acquire land in the area in order to realize its proposed development scheme.

A study of uses in areas adjoining the riverfront should be undertaken to determine whether they will be compatible with proposed riverfront uses. If not, a buffer must be provided between such areas and the riverfront. A landscaped riverfront highway with a wide right-of-way might provide such a buffer as well as access to various areas along the riverfront.

With the information provided by the physical and land-use studies, land may be classified for the uses outlined in Chapter II. To repeat, they are:

1. Uses utilizing commercial navigation.
2. Uses utilizing large quantities of water.
3. Uses utilizing water access.
4. Uses utilizing visual access.
5. Uses subject to only minor damage from floods.

The classification of land within the riverfront area could be indicated on contour maps of the area as shown in Fig. 3. The limits of the

various use areas within the riverfront area can then be refined on detailed maps which would also indicate possible future development. The example, Fig. 4, shows part of the redevelopment plan of the Cincinnati Riverfront which might possibly be classified as an area for uses subject to only minor damage from floods.

One final point that should be mentioned in connection with detailed riverfront land-use planning is public access to the various areas of riverfront activity. A river terminal, for example, would be of particular public interest since there is an interesting activity involved in the maneuvering of barges and handling of cargo. Public access to such areas could be designed so that the public would not interfere with terminal operations. Elevated walkways and promenades could be constructed for this purpose.

Since the riverfront is likely to be a main point of entry to many cities, it is essential that the area be developed so that it is a pleasant place through which to drive or walk. The provision of parks and recreation areas will help provide the atmosphere and attractiveness needed to make such an area pleasant. The landscaping of industrial sites along the riverfront would also help in making the riverfront a more attractive area.

Tools to Carry Out the Riverfront Plan

The tools which a city uses to carry out its proposed riverfront plan depend upon a number of factors. Foremost among the factors is the amount of waterfront land involved and whether the city can afford the financial strain of acquiring the land. If the city

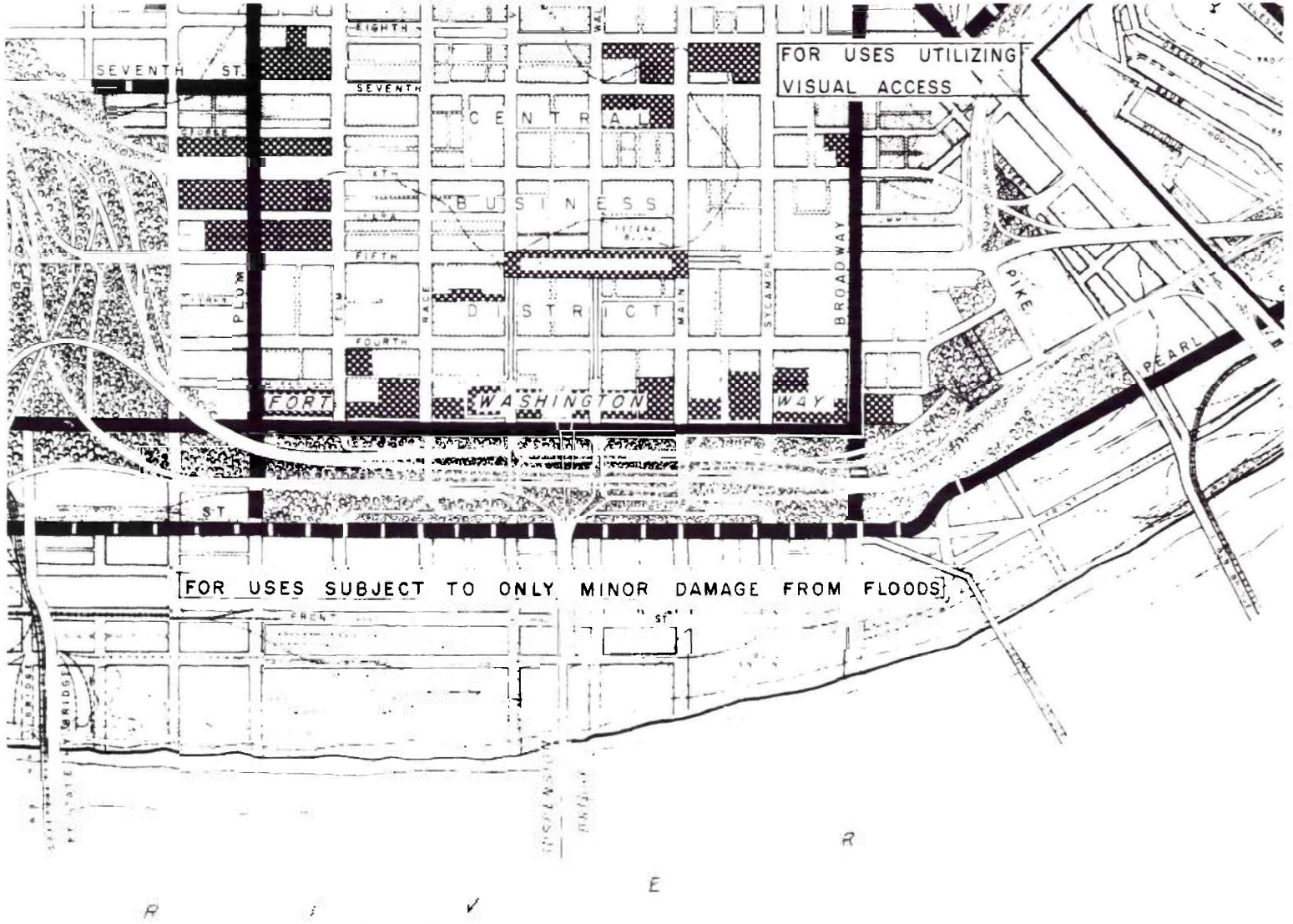

FIG. 3 CONTOUR MAP OF A SECTION OF THE CINCINNATI RIVERFRONT

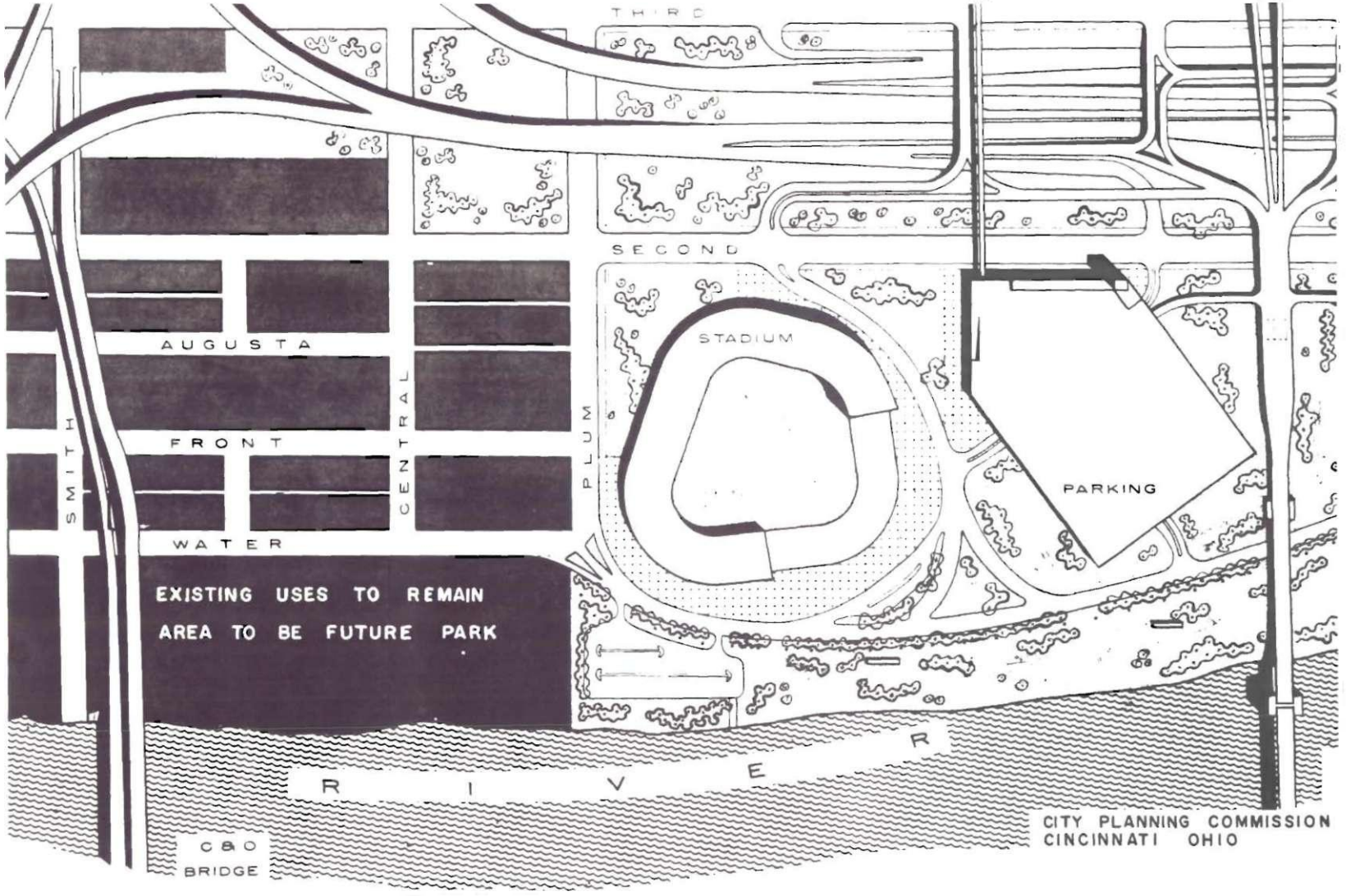

FIG. 4 FUTURE REDEVELOPMENT OF AN AREA SUBJECT TO ONLY MINOR DAMAGE FROM FLOODS

cannot afford this, then it will be left up to private enterprise to develop the riverfront land; in such a case, the police powers of zoning and subdivision regulations would have to be employed. Additional tools are discussed in subsequent pages.

Zoning.--Zoning for industry along the riverfront is one way in which the limited deep-water frontage could be reserved for those industries most likely to utilize commercial navigation. In addition to satisfying the usual requirements regarding smoke, odor, glare, etc., an industry might be required to demonstrate its need for deep-water frontage for commercial navigation before it is allowed to locate in the deep-water frontage area. If the deep-water district were to be designated as RI-1, the requirements might be as follows:

RI-1 Riverfront Industrial District

> The RI-1 riverfront district is established to meet the needs of industries requiring commercial navigation. Since the lands bordering on deep-water frontage are limited, only those industries that demonstrate a need for commercial navigation and those that will not be offensive by reason of emission of smoke, noise,.... will be permitted.
>
> Uses permitted The following uses are permitted subject to the above requirements:
>
> 1. Industries utilizing commercial navigation.
> 2. Boat and shipyards, including repair facilities.
> 3. Wharves and other terminal facilities required for commercial navigation.

A similar industrial district designated as RI-2 could be established for uses utilizing access to large quantities of water. Within this district, any industry would be allowed subject to the

usual requirements but with the added proviso that it use a minimum of 2 to 3 million gallons of water each day in its manufacturing process.

The commercial navigation requirement for the RI-1 district and the water usage requirement for the RI-2 district do not appear to be unreasonable. Since waterfront space is limited, it would be to the advantage of the general public if this land is developed for the purpose to which it is best suited.

Zoning has also been used to regulate development of floodway and impounding areas. A notable example of such regulation may be found in the addition to the Lewisburg, Tennessee ordinance approved by the City Commission on April 13, 1957 (17).

Residential zoning along the riverfront presents the additional problem of esthetics. If the bluffs upon which residential development is planned are low, apartment houses several stories high may not be desirable because they would dwarf the bluffs. If such were the case, the natural scenic beauty of the area would be impaired. A restriction of building heights might be used to prevent such an occurrence. The determination of the proportion of structures to bluffs would have to be made by persons qualified in the field of esthetics who, after a study, would make recommendations to the planning commission.

Subdivision regulations.--Another police-power tool that could be advantageously used in the development of the riverfront is subdivision regulations. The regulations could provide for public access to the river where such land is suitable for access points. Access could be needed for drainage or water lines or for other public purposes in which case only an easement and an access point would be needed. If

some form of development which would decrease public access were to take place, the developer could be required to provide usable public access space by keeping his development a certain distance from the river.

Subdivision regulations could also be instrumental in the design of subdivisions in areas suitable for visual access. The layout of streets could be so regulated as to provide for lots between the edge of the bluffs and the first street to assure the maximum view for residences with no distraction by traffic.

Industrial development commission.--In some cities, it may be financially possible to encourage development of industrial sites by providing land, streets, and utilities on such sites. Development of such sites may attract industries of the kind that can make the most use of the riverfront. It would appear that such lands can be more efficiently developed if they remain in the city's control. As Willbern stated: (18)

> . . ."an integrated, efficient, economical use of limited waterfront areas is more likely if the public owns and allocates the space than if growth is left to haphazard development controlled only by zoning and similar ordinances."

In cities where large-scale public-land acquisition of riverfront land is possible, an industrial development commission under the control of the city government could be established to assure proper development. Such a commission could acquire, plan, develop, and lease or sell sites to industry in accordance with the planning program. Leases could run from 25 to 99 years. A fifty-year lease would justify construction of a plant while still assuring some

flexibility to the future development of the area. Thus, if land presently suitable for access to large quantities of water were in the future to be reclassified for uses requiring commercial navigation, as a result of large-scale dredging operations, the land would be available eventually for such uses. The industrial development commission might also undertake the construction of a general cargo terminal if a study showed such a terminal to be necessary and private enterprise to be unwilling to build one. The problem of what to do with land reserved for industrial development until such time as industries locate there can best be solved by permitting uses which require small capital investments in structures. Such uses might include drive-in theaters and restaurants or, on the edge of the urban area, agriculture.

Urban Renewal.--Public land acquisition for development by an industrial development commission may sometimes be handled most expeditiously by urban renewal. Since the land along many riverfronts is blighted because of disuse and disrepair, cities may have the opportunity to acquire large tracts of land with financial aid from the federal government. With the areas of blight delineated on the detailed, existing riverfront land use plan, urban renewal plans could be formulated so that successive areas along the riverfront could be acquired as time and money permit.

An example of a city which is using urban renewal as a means for acquiring riverfront land is Nashville, Tennessee. In this project, several acres of riverfront land are being acquired as part of a large renewal and redevelopment project.

Public works.--A public-works program carried out in joint participation with the Federal government can also aid in the development of riverfront land. Such a program could consist of construction of protective works, draining or filling of lands, channel dredging and shoreline improvement. Because of the large expenditures involved in such projects, they are usually executed with the help of the Federal government. In such joint participation projects the city as well as the government benefits. The city benefits by being provided the improvement and the government benefits by the improvement of the system of navigable channels. The construction of protective works as a means to acquiring riverfront land is demonstrated by the program in Memphis, Tennessee. The Federal government is to bear the expense of constructing protective works while Memphis is to bear the cost of extending roads and utilities and acquiring land subject to floods. Under construction for several years, the project is now about 72 per cent complete. Approximately 960 acres have been turned over to Memphis for industrial redevelopment (19). Through this project Memphis is able to develop riverfront land for uses utilizing commercial navigation.

Official map.--Another useful planning tool that can be employed to carry out a riverfront development plan is the official map. On this map would be shown existing as well as future streets that will be needed to accomplish the intended plan of the riverfront. The lines of these streets must be plotted accurately. After adoption by the local governing body, the map, which then becomes the official map, is a tool to guide future development by not permitting the construction of

any buildings within the boundaries of a mapped street. Only in the case of extreme hardship to a property owner would any development be allowed to overlap the lines of a mapped street. In such cases a permit to build might be granted subject to requirements governing the location on the property, the height of the building, the kind of materials, the per cent of lot coverage and the duration of the life of the building. The reason for such requirements is to permit the later acquisition of the structure at less expense to the city than if the buildings were constructed without the requirements.

Capital improvement budgeting.--Most of the planning tools that can be used to develop a city's riverfront will require the expenditure of large sums of public funds. Outstanding among these tools that require large expenditures are the city's 1/3 share of urban renewal costs; the city's share of the cost of public-works programs in which the city participates jointly with the Federal government in projects such as land reclamation, protective works and so forth; non-federally assisted public-works projects such as the construction of new streets and utilities and acquisition of riverfront property.

To expedite development of the riverfront after a plan has been made it would seem advisable to determine which of the aforementioned tools should be employed to carry out the plan. The cost estimates should then be included in a Capital Improvement Budget.

If financial conditions of a city permit, a riverfront fund might be established to acquire distressed or tax delinquent property

as it appears on the market. Such a fund would be particularly useful if the property is in an area designated for park purposes and park funds are not immediately available.

Summary

There are numerous ways in which a city can control the development of its riverfront lands. Before any plans are made, however, certain studies are required that will have a bearing on these plans. After these studies have been completed and the plans drawn, the tools discussed in this chapter can be used in combination as an individual city may see fit.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

A city can make the best use of its limited waterfront area by reserving the space for water-related uses. Among these uses are certain types of industries: those that use commercial navigation and those that require large quantities of water. Recreation uses such as marinas and bathing beaches also require waterfront space. In addition, certain utility plants and agricultural uses may also find a riverfront location desirable. Many cities will find at least a part of their shoreline subject to periodic flooding. In such areas, only uses that will neither suffer major damage from floods nor hinder flood flow should be permitted.

To facilitate planning of the riverfront for such uses requires several studies related to the waterfront. A detailed existing land-use study of the riverfront area is of major importance in formulating the future land-use plan of the riverfront. To control development of the future land use, zoning and subdivision regulations are perhaps the most effective tools. Zoning ordinance provisions may contain the requirements that commercial navigation be needed and used by an industry before it is permitted to locate in a district bordering deep-water frontage. A similar requirement can be made in districts designated for uses requiring large quantities of water. In such districts, the need for a specified amount of

water could be made a requirement. Zoning may also control the uses permitted in areas subject to flooding. Subdivision regulations could be particularly useful in assuring public access to the river where needed.

It would be desirable for a city to acquire its waterfront property whenever possible. Such property can then be developed and suitable sites leased or sold to industries by an industrial development commission under the control of the city and working within the framework of a planning program.

The city could also aid further in the development of its riverfront by draining and filling land, improving its shoreline, dredging to provide more deep-water frontage, constructing roads and utilities and by cooperation with federal agencies in the construction of protective works when they are needed.

The development of many American cities began at their riverfronts. Because of the decline in river traffic with the development of rail and truck transport, the riverfront, once the focal point of the city, fell into disuse and disrepair. It is hoped that this study will aid cities to make their riverfronts orderly, efficient, and attractive areas once again.

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